March 2, 1916.

RS
P1, D-5

PRIMARY AND SECONDARY BARK BORERS KILLING YELLOW, SUGAR AND JEFFREY PINES.

The data herein tabulated was collected from the treated trees on the several Insect Control Projects in District-5 (California). A total of 5,796 yellow pines, 391 sugar pines, and 126 jeffrey pines are considered. This data is principally valuable as showing the percentage of trees killed by each species of insect, thereby determining the most injurious insects to each tree species, both locally and throughout the various Forests; the species of insects which will breed on all three pines, although not always primary; and, the secondary species bred by each tree, which may be primary in killing one species of pine, although secondary on the other two, or killing parts of trees, as, for instance, the tops and limbs.

This data has been carefully taken, a separate "form sheet" being used for each tree. In this data we have records of Dendroctonus brevicomis, D. monticolae, D. valens, Melanophila gentilis, Ips confusus, Ips emarginatus, and the pitch moth (Vespamima sequoiae) killing yellow pines (Pinus ponderosa), although the pitch moth, Ips emarginatus and D. valens are decidedly in the minority. In the sugar pine (Pinus lambert-

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" " Bureau of Entomology.

iana the Mountain Pine Beetle (Dendroctonus monticolae) seems to be the only one of any importance, although here also the Red Turpentine Beetle (D. valens), the flathead (Melanophila gentilis), and the engravers (Ips confusus and Ips emarginatus) kill a few trees. In Jeffrey pines we find three important killers, Dendroctonus jeffreyi, Melanophila gentilis, and Ips emarginatus, with Dendroctonus valens and Ips confusus still killing a few trees.

In establishing the identity of the species responsible for the death of each tree, the men employed to take the data were technical men and, in the case of the projects on the Sierra National Forest and Trinity National Forest, men who have had entomological training both in college and field work. As a general rule it is comparatively easy to determine what species of insect kills a tree. The secondary insects are seldom in sufficient quantity to kill a tree; or, the stage of development of the insect will determine which species is initial in the attack.

Most of the trees are killed by species whose work is unmistakable. When other species were held responsible, the one nearest maturity, most numerous, and which apparently girdled the tree was designated as the initial cause. Where the cause of death was in doubt, the sheet was not tabulated. The doubtful sheets were few in number and would not materially

affect any of the deductions herein drawn.

The actual identity of the insect was established by comparison with specimens identified by the Bureau of Entomology. Specimens so identified by comparison are in the collection at the District Office and may be seen at any time.

The following table shows the secondary species recorded on the different trees. Ips confusus, Ips emarginatus and Melanophila gentilis breed numerously in the tops and often in large limbs. These are actual records. A more careful examination of the tops and limbs of all trees would undoubtedly increase the number of Ips confusus, Ips emarginatus and Melanophila gentilis figures, but sufficient has been tabulated to prove the vital importance of destroying secondary insects which are often primary, and consequently the parts of trees which breed them, i.e., the tops and limbs.

SECONDARY SPECIES

Pinus ponderosa:		
	Dendroctonus valens.....	722 trees
	" monticolae.....	117 "
	" brevicomis.....	21 "
	Melanophila gentilis.....	251 "
	Ips confusus.....	302 "
	" emarginatus	24 "
Pinus lambertiana:		
	Dendroctonus valens.....	51 "
	Melanophila gentilis.....	9 "
	Ips confusus.....	7 "
	" emarginatus.....	2 "
Pinus jeffreyi:		
	Dendroctonus valens	4 "
	Melanophila gentilis.....	15 "
	Ips emarginatus.....	39 "

A comparison of these figures, I think, will show

the importance of secondary species on certain species of trees and justifies the contention that a method of control which kills only the primary insect and leaves the secondary insects on that particular tree to breed, by leaving tops and limbs because they are not infested by the primary insect, is faulty. For instance, Ips emarginatus generally secondary on yellow and sugar pines, is a primary insect of considerable importance on Jeffrey pine, killing 10.3% of all the infested trees and on one project, in 1914, 12/7% of 79 trees cut. Again, Ips confusus, generally secondary on Jeffrey and sugar pines, killed 19% of all the yellow pines worked. Species usually classed as secondary or which may be secondary in an epidemic may become primary if left to breed in tops and subsequently become epidemic themselves.

Numerous instances can be cited not only from personal observation but from the histories of French and German Forests. The summers of 1913 and 1914 were noted in the Sierra National Forest for an epidemic of Ips confusus. An examination made at the time proved that these bark borers had emerged from tops of trees broken off by the snow. This snowbreak was extremely heavy and extended over the area covered by the epidemic. But the point is that the epidemic originated in tops and limbs.

In 1909 an epidemic started in an area from which all the logs or trunks of the trees had been removed leaving only the limbs and tops. The logs were taken over a ridge and

sawed at a mill in an adjoining canyon. This was on the northern Sequoia National Forest on Mill Flat Creek. The infestation in the tops and limbs left on the ground was noted the year before the epidemic started and specimens were collected. The summers of 1910 and 1911 saw the destruction of a large amount of reproduction in Mill Flat Creek.

Again in 1913 an epidemic apparently started from the tops left on the ground where mining timbers had been cut. This epidemic was due to a flathead borer (Melanophila gentilis) and the engraver (Ips emarginatus). From a general examination of the area it was hard to say which insect had killed the most trees. Dendroctonus species were not in evidence.

An epidemic is not necessarily due to one species of beetle. Several species may be epidemic on the same area. One species in particular on one control area (the Hayfork Project in the Trinity National Forest) was responsible for the loss of many poles and saplings. The same species also had attacked the tops or upper part of the crown of all trees attacked by Dendroctonus and had killed the tops of many trees not attacked by Dendroctonus. What would be the policy in a case like this (and this condition is more or less true of all our epidemics in yellow pine)? Would it be good policy to treat only the trees and parts of trees attacked by one primary agent and allow the part of the tree breeding the other primary agent to remain without treatment?

This is exactly what we do if limbs and tops are left in control work.

It would seem from this evidence that control of the part of the tree attacked by the primary agent is an incomplete control, even if the factor of wholly secondary insects which damage the wood, limbs, roots, etc., is not taken into consideration.

The following tables give the three tree species of most commercial importance in California, with the number cut on each National Forest, together with the number of trees killed by each primary agent and the relative percentage.

SUMMARY 1913-14-15.

Pinus ponderosa

Yellow Pines Worked:

Trinity National Forest	2,244	trees
Sierra " "	2,057	"
California " "	333	"
Klamath " "	171	"
Stanislaus " "	991	"
	5,796	"

No. Killed by each Primary Borer:

Dendroctonus brevicomis	3,904	"
" monticolae	139	"
" valens	19	"
Melanophila gentilis	603	"
Ips confusus	1,101	"
" emarginatus	4	"
Vespamima sequoiae.....	1	"
Mistletoe	8	"
Unknown	14	"
Windfalls	9	"
	5,796	"

Percentage:

Dendroctonus brevicomis	67.4 %
" monticolae	2.4 %
" valens	.3 %
Melanophila gentilis	10.4 %
Ips confusus	19.0 %
" emarginatus	.1 %
Vespamima sequoiae	.0%
Mistletoe	.0 %
Unknown	.2 %
Windfalls	.2 %

Pinus lambertiana.

Sugar Pines Worked:

Trinity National Forest	147 trees
California " "	33 "
Sierra " "	137 "
Stanislaus " "	74 "
	391 "

No. killed by each Primary Borer :

Dendroctonus monticolae.....	381 trees
" valens	1 "
Melanophila gentilis	1 "
Ips confusus	4 "
" emarginatus	1 "
Mistletoe	3 "
	391 "

Percentage:

Dendroctonus monticolae	97.4 %
" valens	.2 %
Melanophila gentilis	.2 %
Ips confusus	1.0 %
" emarginatus	.2 %
Mistletoe	1.0 %

Pinus jeffreyi

Jeffrey Pines Worked:

Sierra National Forest	117 trees
Trinity " "	9 "
	126 "

Pinus jeffreyi (Contd).

No. killed by each Primary Borer:

Dendroctonus jeffreyi	78	trees
Ips confusus	3	"
" emarginatus	13	"
Melanophila gentilis	29	"
Dendroctonus valens	3	"
	126	"

Percentage:

Dendroctonus jeffreyi	61.9 %
Ips confusus	2.4 %
" emarginatus	10.3 %
Melanophila gentilis	23.0 %
Dendroctonus valens	2.4 %

From the above tables it will be noticed that Melanophila gentilis, Dendroctonus valens, Ips confusus and Ips emarginatus breed on yellow, sugar and Jeffrey pines, that Dendroctonus brevicomis only on yellow pine, Dendroctonus monticolae on yellow and sugar pines, and Dendroctonus jeffreyi only on Jeffrey pine, although the last species has occasionally been found on yellow pine. Taking District 5 (California) as a whole, the primary insects rank numerically, in relation to the damage done, as in the following table:

Dendroctonus brevicomis	1
" monticolae	2
Melanophila gentilis	3
Ips confusus	4
Dendroctonus jeffreyi	5
Ips emarginatus	6
Dendroctonus valens	7

Summarizing the above data it logically appears:

1. That in treating Dendroctonus brevicomis infestations in yellow pine, if the tops and limbs are left to breed Ips emarginatus and Melanophila gentilis, we are leaving them to help kill .4% of infested sugar pines and 33.3% of infested Jeffrey pines.

2. That in treating Dendroctonus monticolae and Dendroctonus jeffreyi infestations in sugar and Jeffrey pines, if the tops and limbs are left to breed Melanophila gentilis and Ips confusus, we are leaving them to help kill 29.4% of the yellow pine infestation.

3. To a smaller extent we are leaving other species which are sometimes primary to kill either the same species of tree or other species of trees.

and finally,

4. Bark borers which breed in tops and limbs have started epidemics and there seems no reason to suppose they will not in the future.

If the above contentions are reasonable and logical, as I believe them to be, it would seem that the following rule is obvious,

Insect control operations to be entirely successful must include the tops and limbs of all trees.

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